LUBRICATION

Published by THE TEXAS COMPANY

17 Battery Place, New York City

Copyright, 1918, by The Texas Company

Edited by

L. H. CANFIELD, Ph. D.

VOL. V FEBRUARY, 1918 No. 4

Published Monthly in the interest of efficient lubrication.

Change of Address—In reporting change of address, give both old and new address.

Reprints—Permission to reprint articles will be granted, provided credit is given to the author and to "Lubrication."

Correspondence is invited. Address all communications to Dr. Canfield.

CONTENTS

	PAGE
Thrift	1
Lubrication of Internal Combustion Engine Cylinders	2
The Machine Builder and the Lubrication Engineer	9
Lubrication of Ball Bearings	11

THRIFT

A NATION that prepares to enter a war first takes stock of fighting men, its guns, its gold and its food. It also will place on the credit side of its books the two items, thrift and courage. Without these two, all the material advantages of trained armies, war chests, fields of grain and wells of oil, will count for little in a long-drawn contest. When disasters fall upon a nation, courage will steel its will. When the costs of war mount up to heights undreamed of before this contest, thrift will win the day.

When the first Liberty Loan was launched, the cry was heard quite frequently that this is not a thrifty nation and that the Continental peoples have outstripped us in the practical application of individual savings to national finances. But those who complained in the early months of 1917, on the eve of the first Liberty Loan, of our unwillingness to save have forgotten what this nation did when put to the test in the days of the Revolution and the Civil War. There is no national aversion to thrift. The first two Liberty Loan campaigns proved incontestably that the American people know how to "save and serve." That they will continue in this self-sacrificing, forward-gazing spirit is not to be doubted. They have heard and heeded the President:

"Let every man and every woman assume the duty of careful, provident use and expenditure as a public duty, as a dictate of patriotism which no one can now expect ever to be excused or forgiven for ignoring."

Our war bills, growing heavier as the climax of the world contest draws nearer, cannot be met however by the same measure of thrift that characterized the first months. The United States must reach and surpass the mark set in France and Great Britain. In England, one bank alone, the London City and Midland, which reaches all social ranks, reports that its depositors applied for $451,198,000 of the last war loan, or considerably more than one-half the amount standing to their credit. This tremendous total could not have been lent to the Government without the most extraordinary thrift and self-denial.

LUBRICATION OF INTERNAL COMBUSTION ENGINE CYLINDERS

By W. F. Osborne*

So much misinformation has been published on the subject of the lubrication of the cylinders of internal combustion engines, that there exists considerable doubt in the mind of the average engineer as to the actual conditions of operation and the characteristics of the oils most suited to meet these requirements and afford continuous operation. It therefore seems desirable to set forth some of the facts for consideration.

The duty of the cylinder of an internal combustion engine differs from that of the cylinder of a steam or air-driven unit in that, in addition to acting as a medium for transmitting the stored energy in the highly compressed gas, it must also act as a furnace for the production of these highly compressed gases from the combustible fuel supplied. The high temperature involved and the necessity for removing the products of combustion from the cylinder impose rather peculiar conditions of service upon the lubricating oil. The requirements of the various types of engines are somewhat different, but owing to the large proportion and the prominence of engines working on the four-stroke cycle, this discussion will cover chiefly what takes place in the cylinders of an engine of this type. From this investigation, the requirements of other types may be ascertained.

Charging Stroke—The cylinder walls, as far as the piston travels, are covered with a film of oil from the previous stroke, which together with the oil on the piston and between the rings, acts as a lubricant for the piston and rings on the charging stroke. The oil also assists the piston rings in forming a seal for the piston, preventing leakage of the air or vapor from the crank case into the cylinder.

Compression Stroke—The film of oil left on the cylinder walls from the charging stroke will lubricate the piston on the compression stroke, and as the piston moves toward the cylinder head, it will smear a fresh film on the walls. The supply of oil, which collects on the advancing side of the piston rings and around the upper edge of the piston, serves to prevent leakage of compressed gases past the piston rings into the crank case, and assists in maintaining improved compression.

Firing Stroke—The film of oil placed on the cylinder walls by the piston on the compression stroke lubricates the piston on the explosion stroke. As the piston moves toward the crank, the walls are exposed to the high temperature of the burning gases, but the flame comes in contact with the oil film only after it has served its purpose of lubricating the piston on the instroke. The greater part of the damage to the oil film undoubtedly occurs on this stroke. The oil between the rings and between the piston and cylinder walls also is subjected to the pressure of the burning fuel and must assist the piston rings in preventing loss of power thru leakage of gases into the crank case.

Exhaust Stroke—If there is any

* Staff Engineer, Lubricating Division, The Texas Company.

trouble with the lubrication, it will be encountered on this stroke, as the oil film on the cylinder walls has just been exposed to the high temperature of the burning gases and has undoubtedly been somewhat damaged. However, if the oil possesses the proper characteristics, some lubricating value remains, which, together with the oil film on the piston itself, lubricates the piston for this stroke.

There are a number of factors in the mechanical construction and in the operating condition of an engine which determine the characteristics of an oil that will satisfactorily meet the requirements above stated. Some of the more important of these are given below, and their effect will be discussed in the order in which they are mentioned:

Temperatures in Cylinders
Piston Clearance
Cooling Systems
Ignition
Fuels
Carburetion
Oiling Systems

Effect of Temperature Conditions—The temperatures existing in the cylinders of a four-stroke cycle engine as given by Lieutenant G. S. Bryan, U. S. N., in his paper on "Motor Cylinder Lubrication," published in the Journal of the Society of Naval Engineers, February, 1915, are as follows:

Maximum temperatures obtained at top of explosion stroke, 2,700° F.

Minimum temperature during suction stroke, 250° F.

Average temperature during the complete cycle, 950° F.

These are the temperatures of the gases in the cylinder, and not the temperatures of the cylinder walls.

Basing calculations on an investigation made by the Bureau of Mines in 1912, of the transmission of heat in steam boilers, it would appear that the temperature of the inner surface of the cylinder wall ranges from 55° to 60° higher than that of the circulating water. Later investigations have shown the temperature difference to be as low as 30° in some instances, depending, to a certain extent, on the cylinder design and the efficiency of the cooling system. As long as the water is not boiling, the cylinder wall temperature, therefore, will hardly be very much higher than 267°, while at normal circulating water temperature of 140°-150° F., the wall temperature will probably range from 170° to 210° F.

The temperature of the center of the piston head, which, in most cases, is not water cooled, varies from 800° F. to 1,300° F.

As previously stated, the greatest damage to the oil film occurs during the firing stroke. The maximum temperature of 2,700° F. occurs when the piston is practically at dead center, and the temperature then rapidly drops as the piston moves toward the crank, uncovering the oil film and exposing it to the flame until the end of the stroke. The outer surface of the oil film in contact with the cylinder walls at the comparatively low temperature of between 170° F. and 210° F. is probably never affected by the high temperatures, but the inner surface of the oil film, directly exposed to the flame, is undoubtedly damaged, probably the greater part being destroyed.

With a maximum gas temperature of 2,700° F. and an average temperature of 950° F., as it is impossible to produce a petroleum lubricating oil of any kind having a flash point over 700° F., it would seem that any oil film would be promptly destroyed, and that a so-called "high flash" oil of 450° F. would afford very little more resistance

to burning than a "low flash" oil of 325° F. under these conditions.

Altho the high temperature of the exhaust gases, around 800° F., continues to destroy the film on the exhaust stroke, the advancing piston smears a fresh film of oil over the cylinder surface, which lubricates the piston for the suction stroke. The cool, fresh charge of fuel, even when mixed with the exhaust gases remaining in the cylinder, does not average over 250° F., so that no damage is done to the oil from high temperatures on this stroke. On the compression stroke, the temperatures do not become very high until the piston has completed the greater part of its stroke, and there is very little effect on the oil film.

The Effect of Piston Clearance—The operation of an internal combustion engine is greatly affected by the degree of perfection of the seal of the piston and cylinder. This seal may be made practically perfect by tight pistons or piston rings, so that no loss of explosive mixture occurs on the compression stroke and no loss of power thru leakage on the firing stroke. A seal effected by mechanical means, however, is secured at the expense of greatly increased friction. In fact, the rings can be made so tight that the engine cannot be turned over at all.

A more desirable form of seal can be secured and maintained by making use of the film of lubricating oil necessarily existing for lubrication. As the piston advances, a quantity of oil builds up on the edge of the piston head and on the advancing side of the rings which opposes the force of the compressed gases, and if the lubricating oil has sufficient body or viscosity to resist the force of the gases, a perfect seal is obtained.

Piston clearances when the engine is cold are, of course, considerably larger than when the engine is at the running temperature, and as a good compression is of the greatest importance in starting a cold engine, the oil film can be of much assistance. Fortunately, petroleum oils have the characteristic of becoming heavier as the temperature becomes lower, so that the film on the cylinder walls will be very much thicker when the engine is cold than later when the engine is warmed up.

A perfect seal maintained by the lubricating oil secures the following benefits:

1. Minimum lubricating oil consumption. A suitable oil, by maintaining a perfect seal, prevents the pressure of compression and explosion from wasting the oil by blowing it off the cylinder walls, past the piston rings. It also prevents excessive quantities working into the cylinder on the suction stroke and being carried into the combustion space, where it is destroyed.

2. Minimum fuel consumption, by preventing leakage of fuel past the rings on compression and waste of power on firing stroke. It does not allow excessive quantities of oil to get into the firing chamber and interfere with the proper combustion of the fuel mixture.

3. Minimum friction, thru the use of looser fitting pistons and rings working on a lubricating film.

4. Minimum carbon, due to minimum quantity of oil working into the combustion space.

5. Where a crank case oiling system is provided, a perfect seal, by preventing the hot gases from reaching the crank case, maintains lower oil temperatures, and thus prevents excessive bearing temperatures and cooling water temperatures.

6. In the operation of crank case oiled engines, a perfect seal is of great benefit, as it prevents liquid

fuel or vapors passing the rings and later condensing into a liquid in the crank case, which destroys the body of the oil. If the oil is thinned down by the admixture of gasoline or kerosene, the body is destroyed to such an extent that the oil is unable to maintain the seal at the original point and the conditions rapidly become worse and worse.

Some elaborate experiments were made in 1911 to determine the cause of this thinning down of the oil. During these experiments many different kinds of oils were run to the breaking point in a Singer motor. An examination of the oil before and after the test showed, in every case, that the body of the oil had become lighter and that the flash point had been lowered, sometimes to the surprisingly low point of 150° F. To determine whether this was caused from the breaking down of the oil or its being thinned by the amount of fuel working past the piston rings, tests were made, using benzol as fuel. The presence of benzol is readily detected in lubricating oil, whereas gasoline or kerosene and the products of decomposition of a petroleum oil, which are similar to gasoline, are not. These tests established the fact that the gas leaked past the piston rings, evidently afterward condensing and affecting the motor oil. As high as 3% of benzol was found in the motor oil after four hours' run. The effect of this admixture of fuel is to lower the flash and fire, make the gravity lighter and lower the viscosity. Many tests made in subsequent years have confirmed these general findings.

Judging from these tests, it would appear that a large proportion of motors of this type operate on an oil which is quite different from the new oil introduced into the crank case. This varying condition of the oil is directly the result of the condition of the engine, and the condition of the engine, as time goes on, is the result of the changed condition of the lubricating oil. What becomes of the argument that a high flash oil is necessary to properly lubricate a motor, when this same oil promptly has a flash point of 200° F., when the motor is warmed up and operating on the road?

Practically every car, after operating for over fifty miles, has an oil in the oiling system quite different from the new oil put in. The change is only in degree, and is determined largely by the original viscosity of the oil and the efficiency of the seal. A suitable cylinder oil therefore, should have the proper viscosity to maintain the most perfect seal under the mechanical conditions formed by the piston clearances and the type and design of piston rings.

The Effect of Cooling Systems—Air-cooled motors, such as motorcycle engines, aeroplane motors and one or two automobile engines, naturally run with much hotter cylinders than the water cooled type. The high temperature of the inner cylinder wall thins the oil down very seriously, and it is necessary that the oils selected have a high viscosity in order not to be thinned down to a dangerous degree. On account of the great expansion of these pistons and cylinders, the piston clearances at atmospheric temperatures are large, and unless properly taken care of by suitable rings, considerable oil sometimes works thru into the combustion space when the engines are first started up, causing bad carbon deposits.

With circulating water cooling systems, it is possible to hold the cylinder wall temperature at a much lower point, and the required

viscosity of a suitable oil will be higher or lower as the cooling water leaving the cylinder jacket is hotter or cooler. There are several devices on the market for automatically or otherwise controlling the cooling water temperature, among them being a system of shutters for regulating the amount of air passing through the radiator, thermostats, etc. The principal result aimed at is an increase in the safe working temperature of the cooling water, with the view of improving fuel economy. An increase of the cooling water temperature to 180° F., or even higher of course results in hotter cylinder walls, which would consequently require a heavier oil to maintain the seal and provide lubrication.

The Effect of Ignition—If ignition takes place at exactly the proper time, resulting in the most complete combustion possible of the fuel supplied, the maximum temperature will occur when the piston is very nearly on the dead center and as the piston recedes, uncovering and exposing the lubricating oil film to the burning gas, the temperature rapidly falls off. If the spark is retarded, a slower and later burning results, extending over a greater portion of the stroke. This longer exposure of the oil film to the high temperature tends to damage it, and the effect may be so severe as to completely destroy the film. Continuous retarded spark operation also quickly raises the temperature of the cylinder walls and the cooling water, thinning down the oil and frequently reducing its viscosity to the danger point.

The Effect of Different Fuels—Natural gas, blast furnace gas, producer gas and coke oven gas, being comparatively slow burning gases, do not produce high temperatures, but the temperatures generated are maintained over a greater portion of the stroke, thus exposing the oil to rather severe temperature conditions. These slow burning gases are generally used in comparatively slow speed engines on account of the time required for complete combustion, and a heavier oil film on the walls is necessary for protection against the long exposure to high temperature than in higher speed gasoline motors.

Kerosene being slower burning than gasoline, permitting of higher compression and requiring with the present methods of carburetion a somewhat higher circulating water temperature, imposes a severe service on the lubricating oil, which must have exceptionally good lubricating qualities to stand up for any length of time. However, as methods of carburetion improve, there should be no reason why the lubricating requirements would be any more severe when using kerosene than when using gasoline fuels.

The Effect of Efficient Carburetion—The question of complete carburetion or vaporization of the fuel has great bearing on the efficiency of lubrication. The ideal condition is, of course, high initial pressure, and very early, complete combustion approaching the gun powder explosion. In this case the maximum temperatures are obtained when the piston completely covers the working surfaces of the cylinder and the lubricating film is not exposed to these extremely high temperatures. If the fuel is not completely vaporized and thoroughly mixed with the proper proportion of air, slow burning occurs, with the bad effects indicated above.

The majority of present-day carburetors handling liquid fuel depend, to a considerable extent, upon the additional vaporizing which occurs in the cylinder during compression,

and when the liquid fuel is drawn into the cylinder in the form of minute drops borne by the inrushing air, on striking the cylinder wall some of the small particles adhere in a liquid form and have a tendency to thin down the lubricating film on both the charging and compression strokes. With too rich a mixture, some condensation also probably occurs during the compression stroke, and either of these two factors may have the effect of working some of the oil off the walls into the combustion space or allowing it to be blown past the piston rings and out of the open end of the cylinder. This is a serious matter on enclosed crank case engines, as the contamination of the oil as stated above has many dangerous effects. The complete vaporization of liquid fuels and the absence of condensation in the cylinders will enable the lubricating oil to perform its duties for a very much longer period than is now the case with greatly improved fuel economy.

Oiling Systems—The method of supplying the oil to the piston and bearings affects somewhat the viscosity of the oils which can be used in that the suitable oil must be thin enough to flow to the parts to be lubricated from the point of supply; but instead of selecting an oil which is suitable for working in the system provided, it seems much better to select an oil suitable for the parts to be lubricated and then arrange the oiling system to properly handle that oil.

Carbon—The most discussed, perhaps because it is the most visible, effect of unsuitable oil, is the carbon deposit in the combustion space, on the valves, on the piston head and behind the rings. An analysis of the carbon deposit in a cylinder generally shows the presence of considerable quantities of dust, drawn in thru the air intake and rust held together with a little oil.

If excessive quantities of oil are used, the amount working past the piston rings into the combustion space will be greater than can be completely burned up before an additional amount is splashed up. In such instances, a part of the oil is burned, another part merely cokes, while the remaining portion of this oil, not having time to burn, remains as oil in the cylinder head, binding together the carbonized portions and rapidly building up a gummy mass. This is particularly likely to happen where rich mixtures are used, because as an excess of oxygen is not originally contained in the mixture, there is no free oxygen to assist in the combustion of the oil. A lean mixture, on the other hand, carrying an excess of oxygen, permits of a greater supply being used for the combustion of the oil, and results generally in much cleaner cylinders. The oil should be of suitable viscosity, and the supply should be so regulated as to prevent excessive amounts working into the combustion space.

Carbon is sometimes formed from the use of motor oils improperly manufactured or refined from unsuitable crudes. It is desirable that the excess quantities of the oil supplied and the inner surfaces of the oil film affected by the high temperatures should either volatilize without decomposition or decompose with the formation of soft soot-like carbon. Volatilized oils are carried out with the exhaust and have no opportunity to form carbon. Free carbon would be carried out with the exhaust or remain in the cylinder and whether or not it would remain in the cylinder would depend greatly upon the oil film upon the piston head, valves and cylinder head. Some oils do not

readily volatilize and form a thick, viscous, gummy deposit, which retains the carbon formation on these surfaces and prevents it from being blown out thru the exhaust; the gummy deposit gradually thickens and hardens, and eventually forms the well known hard crystalline carbon deposit.

Having now discussed some of the important occurrences in the cylinders of an internal combustion engine working on the four-stroke cycle, and having considered some of the troubles arising from improper lubrication, it may be of some benefit to investigate the characteristics of oils which are capable of lubricating the pistons and cylinders under operating conditions. Irrespective of the crude or method of manufacture, the characteristics of an oil suitable for an internal combustion engine might be covered by the following general specifications:

"A motor oil should consist of refined and filtered mineral oils or mixtures, having a cold test of not over 25° F., fully suitable for use in internal combustion engines." An oil meeting these specifications would be perfectly satisfactory when used in an engine for which it was suitable, its suitability being largely determined by its viscosity and certain other features, among them being the ease of starting the engine in cold weather.

There are a number of tests which are made for the purpose of determining the suitability of a lubricating oil, some of which have a bearing on the lubricating quality of an oil and some of which do not.

Gravity—The gravity reading is merely an indication of the crude from which a lubricant is refined, and is no indication of its lubricating value for internal combustion cylinders.

Flash and Fire—Flash and fire tests are no indication of the ability of an oil to stand up under the working temperatures of the cylinders. As stated above, the temperatures in the cylinders are far beyond the highest possible flash test of any lubricating oil, and a high flash oil would afford very little more resistance to destruction than a low flash test oil.

Pour Test—The pour test is an indication of the temperature at which the oil will flow, and where the engine is operated under conditions of temperature below 30° F., the pour test of the oil is of considerable importance. The zero cold test of Texaco Motor Oils makes them particularly desirable for use in engines exposed to low temperatures, especially automobile engines.

Viscosity—The viscosity reading is the measure of the body of the oil, and may also be considered as a measure of the thickness of the film of oil which would be maintained on the cylinder walls. It is also an indication of the ability of the oil to resist the pressure of the explosion gases which tend to force their way past the piston rings. In other words, the higher the viscosity, the greater will be the ability of the oil to withstand the high temperatures encountered, and the better will be the effect in maintaining the piston seal. Oils having a naturally heavy viscosity will give much less trouble from carbon, both in amount and character, than oils having a light viscosity artificially increased by the addition of cylinder stock.

Color—Color in itself is no indication of the lubricating value of an oil. Generally speaking, however, if an oil is a reddish color, having a greenish tinge, it may be assumed that it contains a percentage of

cylinder stock, added for the purpose of raising the viscosity. Texaco Motor Oils are pale filtered oils having a light clear appearance and are remarkably free from carbon forming proclivities.

The writer realizes that there are a number of additional influences affecting the selection of suitable oils, but it is hoped that the points brought out will be of some benefit to those interested in the use and purchase of internal combustion cylinder oils.

THE MACHINE BUILDER AND THE LUBRICATION ENGINEER

IN view of the fact that the efficient operation of any piece of mechanical equipment depends, to a large extent, upon the care taken in the selection and the method of application of lubricants, many progressive machine builders have considered very seriously the subject of lubrication. Realizing the need for the advice of experts experienced in practical lubrication, it is only natural that these manufacturers should turn to the engineering organization of The Texas Company. When a problem is submitted to this organization the design of the machine is thoroly investigated and the conditions of operation are carefully considered by the engineers of The Texas Company before their recommendations are made. Thru this engineering organization, The Texas Company is able to give expert engineering service, providing for all types of machinery the most efficient and satisfactory lubrication. This co-operation of our engineers with the machine builder is well illustrated by the case of the Ottumwa Iron Works, Ottumwa, Iowa.

These people are builders of high-grade steam and electric hoists for mines and quarries, and while these hoists were already quite satisfactory, as engineers desirous of securing the most efficient results, they deemed it advisable to give special attention to the matter of lubrication, and to avail themselves of the service of The Texas Company. After thoroly examining the construction and carefully inspecting the conditions under which these hoists operate, the engineers of The Texas Company recommended Texaco Crater Compound for the lubrication of all gears including spur and herringbone type, both exposed and enclosed in a bath. After an extensive test of this lubricant was made by the Ottumwa Iron Works, they found it so satisfactory and the lubrication of the gears so perfect, that they felt that the use of this lubricant would reduce the cost of repair and replacements to the great benefit of the owner, and they have, therefore, issued the following instructions to the purchasers of their hoists.

Important Lubricating Notice

"Numerous trials of lubricant have been made on our machines in the field, and from results obtained we are convinced that the most efficient gear lubrication can be secured with a product manufactured by The Texas Company, known as Texaco Crater Compound. This is a very dark and extremely viscous lubricant, especially adapted to resist the concentrated pressures encountered in gear service. Once established on the teeth, it retains a protecting film for long periods of time, thus

preventing wear and minimizing noise of operation; and where gears are encased, it can be relied upon to work onto the bearings, furnishing satisfactory lubrication at those points.

"Crater Compound is not affected by acids, dust or heat, so that its use under extreme service influences will net the very best results. A sample of this lubricant is shipped with the hoist, and its use is recommended to insure maximum life and service from the parts. Suggestive instructions as to the most effective and convenient ways of handling the product are submitted in the paragraphs to follow.

Exposed Gears

"Gears not enclosed in oil-tight cases, which would permit the carrying of a bath of lubricant, are required to retain a film on the tooth surfaces for appreciable periods between applications. Also, the teeth are exposed directly to surrounding influences of dust, water, acid fumes, etc., which may be present. Under such conditions, Crater Compound will leave a film on the tooth surfaces capable of withstanding the working pressures, thus reducing wear and noise of operation. The film will not be washed off by water, and will protect despite the exposure to dust, etc.

"Applications are most readily made by pouring on in a *fine* stream from a small spouted container, having the lubricant heated until very thin and directing the stream so as to strike the center of the teeth on the wearing side; with such handling the product will be distributed over the entire surface of each tooth. The lubricant may also be applied in the heated state, using a small brush; but the first method suggested has been found to be the most economical as well as the most cleanly and convenient.

"The frequency of application necessary will vary with the service conditions—from twice per week to once per two or three months. No application is required as long as the wearing sides of the teeth carry a sticky adhesive film of the compound.

Encased Gears

"Where gears are contained in oil tight cases, it is possible for them to dip into a bath of lubricant at all times. Crater Compound admirably adapts itself to this condition, because in addition to its adhesive and protective properties, it is a fluid product and will at all times flow back to a level.

"Accordingly, it is only required that the lower teeth dip into the bath about ½ inch, as these lower gears will carry the lubricant up and distribute it to those meshing with them. Inspection should be made regularly, to make sure that the proper level is being maintained, and quantities should be added only when the level gets below the established point; it is not desired to carry the bath at too great a depth. Besides furnishing lubrication for the gears, the product will work onto the bearings and lubricate them also.

"When subject to exposure to extreme cold conditions, it is recommended that the Crater Compound be reduced with a zero cold test oil. This would apply only to enclosed gear cases, and need only to be practised where the effect of low temperatures is such as to prevent the lubricant from reaching the bearings in a proper manner.

Cable Lubrication

"Crater Compound may also be used with equal success as a wire

rope lubricant. It works into the interstices of the rope, preventing the admission of dust and lubricating the individual strands; furthermore, it will penetrate to the core and prevent rotting at that point.

"Application may be made by pouring on in a *fine* stream, or painting the rope while wound on the drum; in either case the product should be heated until very thin.

General Note

"Unless the parts to be coated have already received an application of Crater Compound, all surfaces should be thoroly cleaned with gasoline or kerosene, so as to remove all traces of lubricant used. The presence of any other lubricant weakens the properties of Crater Compound and prevents its reaching the metal surfaces which is essential in producing the most efficient results."

(Signed) OTTUMWA IRON WORKS,
Ottumwa, Iowa.

It must be very gratifying to the owners and operators of Ottumwa Hoists to know that the builder has so satisfactorily looked after their interests by thoroly investigating the subject of lubrication and providing them with complete recommendations. This co-operation of the manufacturer with the lubrication engineer assures the purchaser of the hoist that one more feature has been made fool-proof. He need not worry his head about trying to find a satisfactory lubricant as it has already been done for him.

On the other hand, he knows that no complaints of cutting gears and hot bearings will be made because he has shown the operator how to correctly lubricate the machine.

LUBRICATION OF BALL BEARINGS

A BALL BEARING is a carefully made piece of mechanism, machined and ground to a ten-thousandth of an inch, fitted and adjusted with great care. The highly refined steel, of which the ball bearing is made, is very susceptible to the effect of acids, which eat away the highly polished surfaces, making them rough and setting at naught all the effort previously employed to make them perfect. The lubricant used, therefore, must be free from any sort of acid or any substance which will cause an acid reaction thru exposure to air or warm temperatures. Greases and oils containing vegetable or fatty oils are particularly subject to deterioration and the formation of acids. A highly filtered straight mineral oil is the best assurance against objectionable action on the polished bearing surfaces.

Because of the close limits of clearances, the ball bearing must not be permitted to run excessivly hot, for the unequal expansion of the metal will cause the bearing to grip with consequent destruction of separator, balls and races. The running temperature of a ball bearing is determined largely by the viscosity of the lubricant. The damage which can ensue from the use of unsuitable lubricants is conclusively demonstrated by an experiment made a short time ago by an engineer of The Texas Company.

A well known type of ball bearing in use on a motor running at 1825 r.p.m. had been lubricated for

twelve months with Texaco Cetus Oil. The manager of the concern operating the motor was induced by a competitor to try out in this bearing, a semi-fluid grease. For this test, the bearing was thoroly cleaned of Texaco Cetus Oil and sufficient amount of the semi-fluid grease put in at five o'clock in the afternoon. At midnight the motor was shut down and an examination of the bearing showed that the lubricant was all gone and the bearing perfectly dry. The shaft collar was cracked and badly scored, the separator was broken up in small pieces and the balls were jammed together so tightly that they could not be moved. Several of the balls were crushed or badly deformed. The races were scored and held bits of metal torn from the balls.

The bearing was replaced by a duplicate, and in order to show more definitely the effect of viscosity, a high grade Texaco Oil of high viscosity was tested in the bearing. After three and one-half hours running the bearing caught fire and the operation was stopped for examination. This bearing very clearly showed the effects of high temperature, all of the balls and races having been burned blue, the separator crushed, and the races very badly damaged. A new bearing was put in, Texaco Cetus Oil, a light bodied oil, was again installed, and after a run of seven hours the bearing temperature was found to be 104° F., at a room temperature of 86° F., the difference due to friction being 18° F. This frictional temperature dropped a little later to 7° F. The heavy viscosity Texaco Oil experimented with, is a very high grade lubricant, which when used for the purposes for which it is suitable, has given excellent results. No doubt the competitor's lubricant also is a very good grade. Undoubtedly either of these lubricants would have been satisfactory if this ball bearing had been running at a much lower speed. At the high speed of 1825 r.p.m. the internal friction of the heavy bodied lubricants created a very high frictional temperature which caused undue expansion of the bearing parts, and destruction of the nice fit and clearance resulted in a seizing of the balls and races.

In selecting an oil or grease for a ball bearing careful consideration should be given to the speed at which the bearing will operate, and the viscosity of the lubricants should be such as to withstand the bearing pressures without creating an excessive frictional temperature. This is an engineering problem to be dealt with in a scientific way.

HOW TO LUBRICATE WIRE ROPE

Total lack of proper lubrication or the use of any so-called lubricating material in the mistaken idea that any kind of lubricant will answer for wire ropes is often the reason why they fail to give the length of service which is rightly to be expected of them.

In selecting a wire-rope lubricant the same careful study of the needs of the lubricated body and the suitability of the lubricant must be made as is needed when providing for the oiling of machinery. Many ropes fail because the inside wire becomes completely corroded before the outside wires have shown any signs of deterioration.

A rope in use is continually subjected, not only to the wear of the drums, sheaves or rollers, but also to a constant wear and friction on the inside, due to the wires in the strands moving slightly when the rope is bent, and this movement, if not lubricated efficiently, eventually causes the wire to fail.

To be of value the lubricant should not only penetrate to the hemp center and thoroughly saturate it, but it should also coat the inside wires thoroughly. A proper lubricant, while doing this, will have sufficient consistency to cling to the rope and not drip off, leaving it practically dry a few days after the application is made.—*Coal Age.*